DEVELOPMENT OF ORGANIC RICE PRODUCTION FOR AGRICULTURAL ENVIRONMENT CONSERVATION IN NORTHERN VIETNAM

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ABSTRACT

Organic farming brings benefits towards food safety and environmental conservation. In order to evaluate the current status of organic rice production in Northern Vietnam, a survey was conducted in three selected provinces in Northern Vietnam, including Son La (mountainous region), Hanoi city (Red River Delta), and Thua Thien Hue (North Central Coast). In each province, two farmer cooperatives that were certified for organic farming (COF) and two other non-certified cooperatives (non-COF) were selected for analysis soil properties and water quality. The area of organic rice production increased but with low area ratio with COF. Soil from organic paddy fields were slightly acidic, with high organic matter and nutrient content. Heavy metal content and water quality parameters met Vietnamese standards. Similar amounts of compost fertilizer were used in all organic farms; however, manure in COF were treated with microbial inoculants during incubation and not in non-COF. Winter crops (soybean, beans, vegetables) were planted in most COF but not in non-COF. The price of organic rice is higher in COF than in non-COF, so it is important to increase COF farms and contracts between farmers and enterprises for organic rice production.

Key words: certified organic farming (COF), compost fertilizer, heavy metals, soil properties

INTRODUCTION

In the absence of chemical fertilizers and pesticides, organic rice production improves rice palatability and protects the agricultural landscape and ecological environment (Noppol et al. 2022; Shaoyi et al. 2023). The demand for domestic consumption and export of organic rice has increased due to the expanding area for organic rice production in Vietnam. The internal standard for organic rice production ("TCVN 11041-5:2018") was issued by Ministry of Agriculture and Rural Development in Vietnam. With its diverse ecological and plant genetic resources, northern Vietnam is one main region for rice production in the country (Goverment of Vietnam 2020; Luo et al. 2014; Mayasuri 2018). Recently, organic rice production has been developed in its northern mountainous region (Son La province), Red River Delta (Hanoi city, Thai Binh and Nam Dinh provinces), and North Central Coastal area (Quang Tri and Thua Thien Hue provinces). The adoption of organic rice production was due to both technical and social factors (Luo et al. 2014; Suminah et al. 2022). A farm can receive an certification for organic rice farming in Vietnam and a certificate from developed countries. However, both the area for organic rice farming and the ratio of areas with certified farms is still small. In order to increase the benefits of organic rice, this study was conducted in order to determine the effect of ecological and social factors, as well as the role of certified farming on organic rice production in

Northern Vietnam, specifically the mountainous region (Son La province), Red River Delta (Hanoi city), and Central Coastal region (Thua Thien Hue province).

MATERIALS AND METHODS

A survey was conducted to evaluate the current status of organic rice production in Northern Vietnam, specifically in five districts from three provinces including Phu Yen district from Son La province, Chuong My and Thanh Oai districts from Hanoi city, and Phong Dien and Huong Tra districts from Thua Thien Hue province. Secondary data was collected from the Vietnamese General Statistics Office (GSO) and Department of Agriculture and Rural Developement of all provinces. In each province, two cooperatives with certified organic farming (COF) and two others without COF (non-COF) were selected for collecting primary data by questionaires with information related to organic rice production, such as natural resources, social condition, materials, fertilizers, and organic rice cultivation techniques.

In 2021, in each organic farm, soil samples were taken from five points and then combined into one sample to measure soil physical and chemical properties. pH was measured using a portable pH meter (ISO 10390:2005), organic matter (OM) via the Walkley-Black method (TCVN 9294 : 2012), total nitrogen content (%) using the Kjeldahl method (TCVN 8557:2010), digestible phosphorus (mg P_2O_5/100g) through the Olsen method (TCVN 8559:2010), digestible potassium (mg K_2O/100g) by Mátlova, flame spectrometery (TCVN 8560:2010), and trace element content (chromium, arsenic, cadmium, lead, copper) by the US EPA Method 200.8 (TCVN 6626:2000; TCVN 6193:1996).

Similar to soil analysis, water samples were collected from five points in each farm, then combined into a single sample for measurement of NH_4^+ through specphotometery (TCVN 6179-1:1996), NO_3^- using the SMEWW-4500 NO_3^- method, Cl^- through the MO method (TCVN 6625: 2000), biological oxygen demand (BOD5) via the sample dilution method with allythioure (TCVN 6194:1996), chemical oxygen demand (COD) through the SMEWW 5220C: 2017 method, dissolved oxygen value (DO) using TCVN 7325:2016, total organic carbon (TOC) by TCVN 6634:2000, and total suspended solids (TSS) by TCVN 6625:2000.

RESULTS AND DISCUSSION

Area for organic rice production. From 2017 up to 2021, the total area for rice production was generally stable in Son La and Thua Thien Hue provinces with a production of 51 thousand ha and 54 thousand ha, respectively (Table 1). Meanwhile, area for rice production in Hanoi city slightly decreased from 189.9 thousand ha in 2017 to 162.2 thousand ha in 2021. The reduction of land for rice cultivation in Hanoi was replaced with other agricultural crops or new industrial and residential areas were developed. From 2017 until 2021, the average area for organic rice production was 113 ha in son La, 280 ha in Hanoi, and 356 ha in Thua Thien Hue. The ratios of organic rice production area to total rice production area were 0.01 – 0.41% in Son La, 0.02 – 0.27% in Hanoi, and 0.62 – 0.68% in Thua Thien Hue. The ratio of organic rice production was the highest in Thua Thien Hue, followed by Son La and lowest in Hanoi, due to more convenient ecological conditions and/or lower labour costs in Thua Thien Hue. The direction of increase in average ratio of organic rice production area in all provinces from 0.22% to 0.45%, which was due to the benefits of organic rice and policy support from Vietnamese Government (Government of Vietnam 2020). Furthermore, certifications for farming of organic rice (TCVN 11041-5:2018) were provided by Vietnamese organizations, such as the Insitute for Standard and Quality Development Study (ISSQ), VinaControl, ISOQ, NhoNho, TQC CGlobal, Greencert, and Vinacert. the Farms also received certificate from foreign countries, such as IMO from Switzerland, ICEA from Italy, COR from Canada, JAS from Japan, and ACT from Thailand. Without a certification,

organic products can not be claim nor labelled; however, the ratio of farm areas certified for organic farming (COF) was very low in all provinces.

The slow increase in area for organic rice production was due to the lack of improving rice varieties, lack of a legal framework, high investment for organic rice, and a complicated and expensive process in providing a certification for organic rice farming (Mayasuri 2018; Parrott et al. 2006). The higher price of organic rice was the most important factor affecting the attitude of farmers towards organic rice cultivation in industrial areas in Indonesia (Suminah et al. 2022). Moreover, factors affecting a householde to adopt organic rice farming include a larger household size, level of education of farmers, experience in crop production and growing mixed crops. Futhermore, government policies and extension activities for implementing effective rice-base production systems towards training farmers, accessing rural credit service, and an agricultural cooperative for sustainable production and marketing of organic rice are necessary (Pornpratansombat et al. 2011; Suminah et al. 2022). Therefore, an estimate price of organic rice production for farmers and companies for their marketing are important for organic rice production in northern Vietnam.

Organic rice yield. Yield of organic rice (ton/ha/cropping season) increased from 2017 to 2021 for all provinces, with an increase from 4.9 to 5.2 ton/ha/season in Son La, from 5.2 to 5.6 ton/ha/season in Hanoi, and from 5.1 to 5.4 ton per ha in Thua Thien Hue (Table 2). Average yield of organic rice (ton/ha/cropping season) was highest in Hanoi (5.38 ton/ha/season), followed by Thua Thien Hue (5.24 ton/ha/season), and lowest in Son La (5.10 ton/ha/season). In all organic rice farms, high quality varieties (J02, BacThom 07, Dai Thom, ST25) were planted. Compared with conventional rice, the average yield of organic rice was lower in Hanoi (93.3%) and Thua Thien Hue (86.6%) due to an improved supply of nutrients from chemical fertilizers used for conventional rice. Average yield of organic rice was 133.8% greater than conventional rice in Son La due to the production of both irrigated rice and rainfed rice with low yield while organic rice was planted only in irrigated areas (Pornpratansombat et al. 2011)

Soil properties of rice paddy fields: Soil type from rice fields producing organic rice in Son La was yellow red soil from metamorphic rocks while ancient alluvial soil was in Hanoi and Thua Thien Hue (Table 3). Soil in all areas were slightly acid with pH values of 3.99 in Son La, 4.98 in Hanoi, and 4.23 in Thua Thien Hue. Organic matter was 2.80% in Son La, 3.80% in Hanoi, and 3.87% in Thua Thien Hue.

Soil macronutrients (nitrogen, phosphorus and potassium content) were highest in Hanoi, followed by Thua Thien Hue, and lowest in Son La. This might be due to the alluvial soil type in Hanoi and Hue while soil type in Son La was yellow red soil from metamorph rocks. The increase in soil nutrient content after a period of organic rice cultivation in alluvial soil in Hanoi and Thua Thien Hue may have contributed to higher soil nutrient content (Bulluck et al. 2002; Nguyen and Pham 2014; Singh et al. 2018). Heavy metal content (Cr, As, Cd, Pb and Cu) was low and is in accordance with Vietnamese standards.

Water quality of rice paddy fields. Water resources for irrigation of rice fields producing organic rice come from streams in Son La. Meanwhile, water resources for Hanoi come from Bui river and from Bo river in Thua Thien Hue. Water quality parameters, including DO, TSS and Cl^- content, were similar in Hanoi and Thua Thien Hue, but lower in Son La (Table 4). On the other hand, other parameters such as NO_3^- and COD were higher in Son La than in Hanoi and Thua Thien Hue due to the presence of rivers in Hanoi and Thua Thien Hue.

Table 1. Total rice and organic rice area in selected provinces in Northern Vietnam

Year	Son La			Hanoi			Thua Thien Hue			Average percentage (%)
	Rice area (1000 ha)	Organic rice (ha)	Percentage (%)	Rice area (1000 ha)	Organic rice (ha)	Percentage (%)	Rice area (1000 ha)	Organic rice (ha)	Percentage (%)	
2017	51.0	3	0.01	189.9	47	0.02	54.9	342	0.62	0.22
2018	50.6	20	0.04	179.5	180	0.10	54.7	353	0.65	0.26
2019	50.8	50	0.1	171.7	315	0.18	54.8	386	0.70	0.33
2020	51.6	170	0.33	165.6	426	0.26	54.5	333	0.61	0.40
2021	51.2	212	0.41	162.2	430	0.27	54.0	367	0.68	0.45
Average	51.0	113	0.18	173.7	280	0.17	54.5	356	0.65	0.33

Table 2. Yield of conventional and organic rice in selected provinces in Northern Vietnam

Year	Son La			Hanoi			Thua Thien Hue		
	Yield of conventional rice (ton ha^{-1})	Yield of organic rice (ton ha^{-1})	Percentage (%)	Yield of conventional rice (ton ha^{-1})	Yield of organic rice (ton ha^{-1})	Percentage (%)	Yield of conventional rice (ton ha^{-1})	Yield of organic rice (ton ha^{-1})	Percentage (%)
2017	3.53	4.90	138.8	5.54	5.20	93.9	5.96	5.10	85.6
2018	3.64	4.90	134.6	5.71	5.30	92.8	6.11	5.10	83.5
2019	3.72	5.10	137.1	5.65	5.30	93.8	5.96	5.20	87.2
2020	3.86	5.20	134.7	5.88	5.50	93.5	5.90	5.40	91.5
2021	4.03	5.20	129.0	6.07	5.60	92.3	6.35	5.40	85.0
Average	3.76	5.10	133.8	5.77	5.38	93.3	6.06	5.24	86.6

Table 3. Soil properties in organic paddy field in selected provinves in Northern Vietnam.

Province	Soil type	pH	OM (%)	Total N (%)	Digestible P (mg/100g)	Digestible K (mg/100g)	Mg^{2+} (mg/ 100g)	Ca^{2+} (mg/ 100g)	Cr (mg/ kg)	As (mg/ kg)	Cd (mg/ kg)	Pb (mg/ kg)	Cu (mg/ kg)
Son La	Yellow red soil	3.99	2.80	0.13	2.1	1.4	12.02	63.03	32.48	11.98	0.04	4.07	4.21
Hanoi	Alluvial soil	4.98	3.80	0.24	18.5	17.8	18.61	87.40	27.69	9.58	0.13	3.69	3.87
Thua Thien Hue	Alluvial soil	4.23	3.87	0.17	9.8	7.3	13.30	44.03	20.95	3.18	0.22	4.48	6.56

Table 4. Chemical characteristics of water in organic paddy field in selected provinves in Northern Vietnam

Province	Water resource	NH_4^+ (mg/L)	NO_3^- (mg/L)	Cl^- (mg/L)	BOD5 (mg/L)	COD (mg/L)	DO (mg/L)	TOC (mg/L)	TSS (mg/L)	As (mg/L)	Pb (mg/L)
Son La	Stream from moutain	0.13	1.30	2.93	14.25	11.04	2.42	6.65	178.84	0.00	0.01
Hanoi	Bui river, Day river	0.41	0.72	20.57	12.51	6.23	4.30	7.03	194.76	0.00	0.01
Thua Thien Hue	Bo River	0.79	0.66	25.45	11.96	6.11	4.17	7.36	211.15	0.00	0.01

Note: BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; DO: Dissolved Oxygen, TOC: total organic carbon; TSS: Total Suspended Solids)

Cultivation techniques and price of rice in COF and non-COF fields. Rice cultivation area from each farming household was larger in COF (0.17 - 0.30 ha) than in non-COF (0.15-0.25 ha) (Table 5). This was in agreement with previous reports indicating the availability of independent production facilities. The perception and appreciation of the community towards organic agricultural products were significant towards the implementation organic rice farming (Samidjo et al. 2023).

Cropping pattern was different between farms with COF and non-COF farms. In COF farms, three cropping seasons per year were implemented namely, spring (rice-), autumn (rice-), and winter (soybean, mungbean, vegetables). Meanwhile, in non-COF farms exhibited two cropping seasons per year namely spring (rice-) and autumn (rice). Animal compost (cow, pig, chicken) were used in similar amounts (4-6 ton/ha/season) in both COF and non-COF farms. However, the manure was treated with microbial products and incubated for at least 2 months before using the compost in COF. The amount of industrial micro-organism fertilizer utilized in COF was lower (1.0-1.3 ton/ha/season) than in non-COF (1.5-1.8 ton/ha/season).

A previous study reported a high level of compost (10-15 ton/ha/season) and micro-organism fertilizer (0.20-0.25 ton/ha/season) were applied in organic rice farms in Chuong My district, Hanoi city. Therefore, soil properties, including organic matter content and aerobic micro-organism population, increased after a few years of organic rice cultivation (Nguyen and Pham 2014; Singh and Singh 2019).

The price of organic rice under organic quality standards (TCVN 11041-2:2017) was 35000-39000 VND/kg or 159 - 177% greater than conventional rice (22000 VND/kg). Certified organic rice with brand names such as Phu Yen in Son La; Dong Phu in Hanoi, and An Lo in Thua Thien Hue increased economic benefits over non-labelled rice, which was consistent with previous reports (Shingo and Hayashi 2011; Nguyen and Pham 2014; Samidjo et al. 2023). Before each cropping season, a contract for organic rice consumption was signed between COF collective farmers and companies as Que Lam Ltd. and Bao Minh Ltd. in Son La, Bao Minh Ltd. and Green Path Vietnam Ltd. in Hanoi, and Que Lam Ltd. and Hue Viet Ltd. in Thua Thien Hue.

Soil and water properties in COF and non-COF fields. pH values, OM, contents and digestible P from the soil were higher in COF than in non-COF (Table 6). Most heavy metals (Cr, As, Cd, Pb, Cu) were significantly lower in COF than in non-COF. The water from COF fields exhibited higher DO values but lower NH_4^+, NO_3^-, Cl^- and COD values than in non-COF fields due to a longer period of implementation of chemical fertilizers, herbicides, and pesticides for conventional rice production (Noppol et al. 2022).

Table 5. Cultivation techniques and rice consumption of paddy field with COF and non-COF

Paddy field	Organic rice area/ household (ha)	Crops in winter season	Yield (ton ha^{-1})	Compost (ton ha^{-1})	Industrial organic fertilizer (ton ha^{-1})	Organic rice price (VND/kg)	Percent of conventional rice (%)	Cooperation with enterprises
COF	0.17 - 0.30	Soybean, beans, vegetables	5.58	4 - 6 (manures with microbial products)	1.0-1.3	35000 - 39000	159 - 177	Contract
non-COF	0.15 - 0.25	No crop in winter	5.52	4 - 6 (manure without microbial products)	1.5-1.8	25000 - 28000	113 - 127	No contract

Note: COF: Certificated Organic Farming

Table 6. Soil properties and water quality of paddy field with COF and non-COF

	Paddy field	pH	OM (%)	Total N (%)	Digestible P (mg/ 100g)	Digestible K (mg/ 100g)	Mg^{2+} (mg/ 100g)	Ca^{2+} (mg/ 100g)	Cr (mg/ kg)	As (mg/ kg)	Cd (mg/ kg)	Pb (mg/ kg)	Cu (mg/ kg)
Parameters in soil	COF	4.52*	3.59*	0.19	11.21*	8.88	14.30	63.50	23.76*	5.44*	0.11*	4.06*	6.13*
	non-COF	4.35	3.13	0.17	9.27	8.51	14.82	62.90	30.68	6.76	0.20	4.86	7.35

		NH_4^+ (mg/L)	NO_3^- (mg/L)	Cl^- (mg/L)	BOD5 (mg/L)	COD (mg/L)	DO (mg/L)	TOC (mg/L)	TSS (mg/L)	As (mg/L)	Pb (mg/L)
Parameters in water	COF	0.85*	0.93*	18.56*	12.66	8.49*	3.29*	7.35	213.06	0.00	0.01
	non-COF	0.90	0.97	21.64	12.67	8.97	3.00	7.28	212.75	0.01	0.01

Note: CO: Certificated Organic Farming: DO: Dissolved Oxygen, TSS; Total Suspended Solids); BOD (Biological Oxygen Demand); COD: Chemical Oxygen Demand; TOC: Total Organic Carbon.

*: Significant at the 0.05 probability level by T-test.

CONCLUSION

Area for organic rice production has increased in Northern Vietnam but there were low ratios of area with COF fields. Soil from paddy fields producing organic rice were slightly acidic, with high organic matter and high nutrient content. Heavy metal content and water quality parameters met the requirements of Vietnamese standard. Compost fertilizer was used in similar amounts in all organic farms, however, the manure was treated by microbial inoculants during incubation in COF farms, but not in non-COF. Winter crops (soybean, beans, vegetables) are planted in most COF and not in non-COF. The price of organic rice is higher in COF than non-COF so it is nesessary to increase COF farms and contracts between farmers and enterprises for organic rice production.

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